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# Slack Capacity: Productive or Wasteful?

*By* WALTER Y. OI*

"Full employment" is an ill-defined concept which means, of course, that slack is also poorly defined. Some idleness is surely part of an optimal allocation of resources. Slack may, however, be wasteful when it is generated by market imperfections. Slack capacity in the *U.S.* economy has apparently been declining over time, and this trend can be explained by received economic theory.

## I. The Phenomenon of Idleness

Resources are never fully employed. An employed worker is "idle" fully three-fourths of the time. Over half of all factories are closed at nights and on weekends. Labor utilization rates, especially unemployment, have been analyzed in the literature, but W. H. Hutt was the one who emphasized the fact that idleness characterized the utilization of all resources, human and nonhuman. Idleness can occur in an equilibrium state as a result of an efficient organization of production. Other forms of "wasteful" slack may, however, be due to market failures. The observations that motivated this paper are described by four stylized facts.

A: Capital utilization rates have increased over the last four to five decades. Murray Foss (1963) reported that manufacturing equipment utilization rates had increased by one-third to one-half over the 1929–55 period. The corresponding increments were 20 percent in mining and 60 percent in electric power generation. In a recent study, Foss (1980) found that the workweek of fixed manufacturing plants (measured by hours per week) increased by 24.7 percent from 1929 to 1976. Similar upward trends were also reported by Charles O'Connor, and Roger Betancourt and Christopher Clague (1978).

B: The relative pay premium for late shift work has evidently declined. O'Connor, using BLS data, found that the average hourly earnings for the day shift rose by 31 percent over the 1960–67 period, while the late and night shift differentials increased by 14 and 15 percent, thereby reducing the size of the relative shift differential in spite of a relative increase in late shift employment.

C: The prices of capital goods measured in wage units have declined. Reliable statistics properly adjusted for changes in durability and quality are difficult to assemble, but the available data indicate a sharp fall in the relative price of new capital goods.[1]

D: Over time, capital goods are becoming less durable. According to Martin Feldstein and Michael Rothschild (p. 409), the average expected life of new nonfarm investment fell from 19.8 years in 1929 to 15.3 years in 1963. The age distributions for the stocks of automobiles, trucks, and aircraft which reflect actual scrapping (as opposed to expected lives), have exhibited leftward shifts over time.

These stylized facts can, I believe, be explained by received economic theory.

## II. Optimal Utilization in a Putty-Clay Model

There is a class of deterministic models in which a higher utilization rate increases output, but it also raises some input prices. An optimal utilization rate balances these two opposing forces. Models differ in the

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[1]Data from the *Historical Statistics of the United States* reveal that the ratio of the wholesale value of a new car to the average hourly earnings of a production worker was $(V/W)=967$ hours in 1940. By 1970, the labor requirement for a higher quality new car was only 659 hours. The BLS producer price indexes for new capital equipment and for new construction rose more slowly than almost any series for wage rates.



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specification of the production function and the way in which increasing use affects input prices.

In the Winston-McCoy model, a firm chooses instantaneous input rates for labor $L$ and the capital-labor ratio, $Y=K/L$, which determines potential daily output, $\bar{Q}=Lf(Y)$. (Gordon Winston and Thomas McCoy, hereafter W-M, assume first-degree homogeneity.) *Ex ante* substitution is assumed, but once $Y$ is chosen, the firm is frozen into a putty-clay technology. Actual output is proportional to the utilization rate, $Q=U\bar{Q}=ULf(Y)$. The daily rental of a machine, $R=V(r+d)$, is independent of $U$, but the daily wage is an increasing function of $U, W=W(U)$ with $W', W''>0$.[2] An efficient plan is one in which the capital-labor ratio $Y$ and utilization rate $U$ are chosen to minimize the total long-run cost for a given rate of output; i.e., minimize $C=(W+RY)L$, where $L=Q/Uf(Y)$. The first-order conditions are

$$\text{(1a)} \quad cUf_Y'=R,$$

$$\left[c=\frac{W+RY}{Uf(y)}=\text{minimum unit cost}\right]$$

$$\text{(1b)} \quad W'(U)=\frac{W(U)}{U}=\frac{RY}{U}$$

In equilibrium, the marginal value product of capital, $cUf_Y'$, is equated to the rental $R$, and the incremental labor cost for a longer workday is balanced against a falling "price" for the service flow from capital. The optimal values of $Y^*$ and $U^*$ are thus determined by relative input prices, $[R/W(U)]$ and properties of the production and wage equations. The W-M model yields two propositions, namely if the elasticity of substitution is less than unity, $\sigma<1$, the optimal utilization rate $U^*$ will rise when (a) $[R/W(U)]$ is increased and (b) the amplitude of $W(U)$ is dampened meaning a smaller shift differential.[3]

In the W-M model, some slack is optimal because workers demand compensating wage differences for longer workdays. The model must, however, appeal to exogenous changes in the relative rental price of capital or in the premium required for longer shifts if it is to explain the secular trend in utilization rates.

The utilization rate can be varied by changing the length of a shift or the number of shifts. Models dealing with the latter discrete choice still assume a putty-clay technology but they replace the continuous wage equation with a shift differential; that is, the wage on the late shift is some multiple $(1+\alpha)$ of the day wage. The results are, however, qualitatively similar to the W-M model. Thus, Betancourt and Clague (1975) find that the conditions favoring multiple shift operation include (a) larger returns to scale, (b) a larger capital share of total costs, and (c) a small shift differential $\alpha$. The discrete choice model is useful for econometric research, but it does not explain differences across shifts in the same factory; why is labor productivity lower on the late shift?

## III. Variable Proportions and the User Cost of Capital

In several models, the capital utilization rate $U$ appears as an argument of the production function, $R=f(U,K,L)$. The wage rate is constant, but $R$ is an increasing function of $U$ because greater use presumably increases the depreciation rate $\delta$; i.e., $R=V(r+\delta)$, with $R_U=V\delta_U>0$. Unambiguous results can only be obtained by imposing restrictions on the production function. In the Epple and Zelenitz model, $U$ and $K$ do not appear as seperate arguments; only their product, $X=UK$, representing machine

[2] The daily rental $R$ is determined by the price of the asset $V$, the interest rate $r$, and the constant depreciation rate $\delta$. The wage equation could be derived from utility maximization where $W'$ and $W''$ reflect a diminishing marginal rate of substitution of leisure for income. This is surely implied in the W-M model.

[3] An increase in $R$ will reduce $Y^*$, but $RY^*$ depends on $\sigma$. If $\sigma<1$, $RY^*$ will rise, and $U^*$ must be increased to restore equilibrium. In the special case of a Cobb-Douglas production function where $\theta$ is capital's constant share of output, equation (1b) can be simplified to $(1-\theta)W'(U)=W(U)/U$. Hence, $U^*$ is independent of $R$ for this production function.

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hours, is entered in the production function, $Q=f(X,L)$. The minimization of total cost, $C=WL=RK=WL=R(X/U)$, yields the following first-order conditions:

$$(2)\quad Q=f(X,L),\ \frac{f_X}{f_L}=\frac{(R/U)}{W},\ \delta_U=\frac{r+\delta}{U}$$

Only the last equation determines the optimum utilization rate $U^*$ which equates the marginal to the average user cost of capital. Thus, $U^*$ is independent of $W$, $V$, and the elasticity of substitution $\sigma$; it is chosen to minimize the cost of the service flow $(R/U)$.[4] A higher rate $r$ will increase both $U^*$ and $(R/U^*)$ which leads to a lower capital service flow per worker,$(X/L)$. These results differ from the W-M model, but the approach is qualitatively similar.

## IV. Maintenance and Non-Linear Depreciation

In most models, the depreciation rate $\delta$ is assumed to be constant over the machine's life, but $\delta$ can depend on other variables. The assumed constancy of $\delta$ must be questioned in the light of data on the prices of used assets. The price of a used machine declines with increasing age in a non-linear fashion because of deterioration (due either to output or input decay) and technical obsolescence. The rental of capital must cover the amortization of the asset's value as well as maintenance costs $\mu M$ that are required to "produce" a service flow from capital; i.e., $R=V(r+\delta)+\mu m$, where $\mu$ is the price for a unit of maintenance input $m$. The technology usually involves input decay meaning that older machines require more maintenance to sustain their productivity.

An optimal scrapping age (defining the economic life of a machine) is determined by the age profiles of used asset prices and maintenance costs. The differential between the value of a used machine $V$ and its scrap value $S$ decreases with increasing age, while maintenance costs rise. Following Richard Parks, a machine will be scrapped and replaced when maintenance costs exceed the net value of a machine, $\mu m \geqslant (V-S)$. Depreciation is endogenous. A fall in the price of new machines shifts the $(V-S)$ profile downward reducing the optimal scrapping age. The firm substitutes more of the cheaper capital for less maintenance labor. Taxes and subsidies could result in socially wasteful replacement policies.[5]

The forces that determine the optimum scrapping age are also responsible for the inverse relation between a machine's age and its utilization rate. This result follows from equation (1b) of the W-M model, where a newer machine will be more intensively utilized because it entails a higher capital charge, $RY$. If the user cost of capital is incorporated into the W-M model, this inverse relation is reinforced. If $\delta$ and $m$ are increasing functions of $U$, the firm faces a rising cost of capital.

$$(4)\qquad R'_U=\frac{dR}{dU}=V\delta_U+\mu m_U>0$$

Equation (1b) is now replaced by

$$(5)\qquad W'(U)-\frac{W(U)}{U}+YR'_U=\frac{RY}{U}$$

Technical obsolescence accounts for a larger share of depreciation of newer machines implying that $\delta_U$ will be smaller. Further, the additional maintenance which accompanies more intensive use $m_U$ is likely to be larger for older machines. Both factors lead to a more rapidly rising user cost $R'_U$ for

[4]Dennis Epple and Allan Zelenitz were concerned with the way in which a rate of return constraint affects a firm's choice of the utilization rate $U$ and built-in durability $b$. The rental rate of capital in their model is given by $R=V(b)[r+\delta(b,U)]$. They show that a regulated firm will *not* minimize $R$ in maximizing constrained profits.

[5]When the federal capital grants subsidies paid for three-fourths of the price of a new bus, the optimal scrapping age which minimized the private bus line costs fell from 25 to 13 years. More frequent replacement was the means by which the company substituted cheaper capital for nonsubsidized maintenance labor. William Tye estimated that fully 25 percent of the capital grants subsidies were thus "wasted." Retirement of equipment prior to its socially optimal scrapping age is a form of "enforced idleness" that represents a deadweight welfare cost.

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older machines. As a consequence, older machines are less intensively utilized.

### V. Firm Size and the Organization of Production

Large and small firms in the "same" industry differ in several important respects; large firms (a) choose more capital-intensive production techniques, (b) utilize capital equipment and plant more intensively, (c) pay higher wages, (d) adopt less flexible production methods when judged by *ex post* substitution elasticities, and (e) produce standardized as opposed to customized products.

The optimum firm size defined by the output rate at which $ATC$ is a minimum, reflects a balancing of scale economies from mass production and integration and of diseconomies arising out of the fixity of the entrepreneurial input. All firms might, for example, face the same production function, $Q=\phi(L,K,E)$ with small firms having small endowments of entrepreneurship $\bar{E}$. If $\sigma_{KE}>\sigma_{LE}$, the output expansion path in the range of diminishing returns will entail more capital-intensive techniques. This could account for a higher $(K/L)$ ratio in larger firms.

Suppose that entrepreneurship is described by ability $\varepsilon$ and managerial time $T$. An entrepreneur with greater ability, (large $\varepsilon$), faces a higher shadow price of time. He can economize on the use of this scarce input in at least two ways: (a) by substituting hired inputs for managerial time; or (b) by shifting the product mix away from goods and activity that place high demands on time. Monitoring input performance is a time intensive activity. A large firm with a higher shadow price for management time is thus more likely to adopt capital intensive methods because machines are more easily monitored than men. Production will be organized around teams and units whose performance can be more cheaply monitored. Further, monitoring outcomes is easier than monitoring inputs. The correspondence between outcomes and inputs can be more closely controlled by standardizing products and operating procedures. The latter usually involve rigid production schedules and fixed factor proportions which simplify the task of determining whether workers are following prescribed "efficient" production methods. Larger firms have to pay higher wages because workers must be paid compensating wage differentials to attract them into employments that require strict conformance with rigid, prescribed routines. With standardized operations, the large firm can design specialized equipment that reduces costs. If factor prices and product demands shift, the specialized capital entails a higher risk of technical obsolescence resulting in a higher capital charge $RY$. These higher capital costs prompt the large firms into choosing higher equilibrium utilization rates via multiple shifts.

Little firms are characterized by small endowments of entrepreneurial ability $\bar{\varepsilon}$ and low shadow prices for managerial time. They have a comparative advantage in time intensive activities like monitoring and observing individual worker performance. Jobs may be tailored to fit individual preferences. Workers can be reassigned and tasks redesigned to achieve better matches thereby enabling small employers to hire labor at lower wages. Because observation of individual performance and reassignment to new tasks are costly in terms of managerial time, larger firms devote more resources to recruiting and screening job applicants. We do indeed observe that hiring and recruiting costs in relation to total labor costs are higher for larger firms.

The product mix also varies with firm size. Customized goods are produced in small batches which are unsuited to capital-intensive, volume production. Small firms are better able to provide the flexible, adaptable organizations that can meet the shifting demands for customized, labor intensive goods. They will also buy general purpose, as opposed to specialized, equipment. Moreover, their lower labor costs give small firms an advantage in producing "maintenance." Hence, I would predict that smaller firms are more likely to buy used equipment and to scrap existing equipment at older ages. The user cost of capital $R'_U$, is thus likely to

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be higher for smaller firms leading to a lower capital utilization rate.

## VI. Size of the Relative Shift Differential

The higher capital utilization rate has been achieved by increasing the proportion of workers on late and night shifts. Over the 1960–67 period, the pay differential for late shifts declined in spite of an increase in relative employment on late/night shifts. Marris argued that there may be some external scale economies which affect the private costs of working at night. When only a few work on late shifts, the size of the "night workers market" is too small to sustain frequent transit service and open shops at odd hours. When public transit serves as the travel mode, regular daytime work entails a lower "full cost" for a worktrip because of more frequent bus service. If, however, the worker travels by auto, congestion and parking costs are lower at night resulting in a negative full cost differential for late shift work. An expanded night workers market and the shift to increased auto use may have been responsible for the smaller compensating wage differential that is now paid to late shift workers.

## VII. Concluding Remarks

Hutt identified eight categories of *idleness* of which five can properly be classified as wasteful.[6] Productive slack is exemplified by Hutt's concept of pseudo idleness:

> One of the most common forms of "pseudo idleness" is that which exists when resources are being retained in their specialized form (i.e., not being scrapped) because the productive service of carrying them through time is being performed. This condition exists when their capital value is greater than their net positive scrap value while their immediate hire value is nil.
>
> ...The bottling apparatus of a jam factory may be still for the early hours of each conventional working day. Such regular, recurring idleness can be confidently classified as "pseudo idleness." Spasmodic "pseudo idleness," on the other hand, can often be distinguished from idleness in other senses only with much uncertainty.
>
> [pp. 84, 85, 87]

Transaction costs and input supply prices during idle periods are simply too high to permit the emergence of positive "hire" or rental values.

The deterministic models examined in this paper generated equilibrium slack as part of an efficient organization of production. The equilibrium utilization rate depends on wage and user cost functions as well as on the age profiles of maintenance and depreciation. It seems reasonable to suppose that technical advances were responsible for the secular decline in the price of capital goods $V$, and that investments in human capital raised real wage rates. The higher wage increased the price of maintenance $\mu$ which in combination with a fall in $V$, led to earlier scrapping ages. The age distribution of the capital stock has thus shifted to the left meaning a less durable capital stock. Each machine yields a smaller service flow over its now shorter economic life, but the service flow per year off machine life is higher. Maintenance and non-linear depreciation can thus lead to a higher utilization rate in response to a decrease in $(V/W)$.

In Section V, I sketched the outlines of a model in which the equilibrium size distribution of firms in a given industry is determined by relative factor prices, product demands, and the distribution of entrepreneurial abilities. A fall in the relative price of capital goods $(V/W)$, redounds to the benefit of the larger, capital intensive firms. The relative price of standardized products will fall. Since large firms choose higher, equilibrium utilization rates, the mean utilization rate for all firms will rise. The equilibrium size distribution of firms will shift to the right, but this ought not to be interpreted as an anticompetitive change in the structure of an industry. The stylized

[6] Hutt's eight categories are valueless resources, pseudo idleness, preferred idleness which applies only to labor, participating idleness, enforced idleness, withheld capacity, strike idleness, and aggressive idleness. The last five categories are the results of monopolistic market conditions or government restrictions.

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facts of Section I can thus be explained by received economic theory as the market responses to changing relative factor prices.

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